

4-23-1981

## Trial Transcript, Vol. 46, Afternoon Session

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case # 4993

File # 153

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IN THE DISTRICT COURT FOR THE FIFTH JUDICIAL DISTRICT  
WASHAKIE COUNTY, STATE OF WYOMING

IN RE: )  
)  
THE GENERAL ADJUDICATION )  
OF RIGHTS TO USE WATER )  
IN THE BIG HORN RIVER )  
SYSTEM AND ALL OTHER )  
SOURCES, STATE OF WYO- )  
MING. )

Civil No. 4993

5/1 1981  
Margaret V. Haughton CLERK  
DEPUTY

VOLUME 46

Afternoon Session

Thursday, April 23, 1981

**ORIGINAL**

(The following proceedings  
(were continued at 1:04 p.m.

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THE SPECIAL MASTER: Please come to order.

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Mr. White?

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MR. WHITE: For the purposes of the record,  
Your Honor, the State has just been handed seven  
replacement pages for Dr. Mesghinna's report which  
we received on Monday.

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THE SPECIAL MASTER: Very good. Mr. Clear?

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MR. CLEAR: Your Honor, during the lunch  
break Dr. Mesghinna reminded me that we have some  
illustrative exhibits which are helpful I think to  
explain his testimony. They are real evidentiary  
in nature, they are more just drawings, but I think  
they will put things in focus. I don't know whether  
they have been shown to Mr. White.

MR. WHITE: I think most of them have, and  
as we go through them --

MR. CLEAR: There are only four or so, I  
think.

MR. WHITE: If I have any problems, I'll  
let the Court know, Your Honor. But I have several  
of those, pictures of four of them, so we will see  
if they are the same four.

MR. CLEAR: Okay, fine.

(CONTINUED) DIRECT EXAMINATION

1  
2 BY MR. CLEAR:

3 Q Dr. Mesghinna, I have hung on the easel what's  
4 been marked as United States Exhibit WRIR  
5 C-246. Are you familiar with that exhibit?

6 A Yeah, I'm familiar.

7 Q Okay.

8 MR. WHITE: What was the answer? I  
9 couldn't hear it from here.

10 THE WITNESS: Yes, I'm very familiar with  
11 it.

12 Q (By Mr. Clear) Is this exhibit relevant or  
13 helpful in your explanation of your testimony  
14 on evapotranspiration?

15 A Yeah, it is important not only for evapo-  
16 transpiration, but as we go along we can picture  
17 what we are talking about, so I can explain  
18 really what we mean by crop consumptive use  
19 just from this.

20 Q Okay.

21 A So if I may, shall I go into this?

22 Q Sure.

23 A Of course, this is the ground that we are  
24 irrigating, and let's assume that crops are

25 mesghinna-direct-clear



1 growing, and for time being let's assume there's  
2 only one crop there and let's assume that this  
3 is alfalfa, just to make things easier. The  
4 crop as we can see above the surface, it lives  
5 in soil, and below the surface we can see the  
6 roots penetrate. Okay, what happens is when we  
7 apply water by irrigation, by side roll, this  
8 is side roll or other means of irrigation, the  
9 water comes out as we can see with these drops.  
10 Some of it will be retained on the leaves of the  
11 plants, some of the water will enter deep in  
12 the roots in here, and some of the water will  
13 go out a surface runoff due to the soil. Some  
14 of the water will evaporate from the soil  
15 surface, and after the water enters down here  
16 and taken by the roots of the crop, then the  
17 water has demanded by the atmosphere -- or by  
18 the climate in here will be transferred from  
19 the root zone in the plants. After the plant  
20 uses the water, the water will be transpired.  
21 The amount of water which we are going to discuss  
22 later on that passes the root zone then goes  
23 through deep percolation, that is the amount  
24 of water that's not going to be used by the plant

25 mesghinna-direct-clear

1 at all. It passes beyond the root zone, and  
2 then it will be collected by the drains as we  
3 can see the drains in here, and it will be taken  
4 out from the fields. So really what we discuss  
5 when we talk of crop water use, we are merely  
6 talking about the transpiration from the plant  
7 and evaporation from the soil. That is what  
8 makes evapotranspiration equal to transpiration  
9 plus evaporation. And as we can see, this will  
10 have use in the future, there will be water  
11 that's not going to be used by the plant.  
12 Some of it goes to surface runoff, some of it  
13 goes to deep percolation, and we see how we  
14 are going to collect or how we are going to  
15 come up with the necessity -- the necessary  
16 amount of water for the plant. So I hope this  
17 one shows a pictorial view of the situation.

18 THE SPECIAL MASTER: It is helpful.

19 THE WITNESS: Okay.

20 MR. CLEAR: Your Honor, I'll move the  
21 admission of that exhibit just for illustrative  
22 purposes.

23 THE SPECIAL MASTER: No objection or no  
24 voir dire?

25 mesghinna-direct-clear

1 MR. WHITE: No objection with respect --

2 THE SPECIAL MASTER: So WRIR C-246 is  
3 admitted into evidence. It is a crop water  
4 use illustration.

5 (Whereupon, U.S. Exhibit  
6 (WRIR C-246 was hereby  
(admitted into evidence.

7 Q (By Mr. Clear) Dr. Mesghinna, I think where  
8 we stopped at lunchtime was I think we had  
9 gone into the third step of evapotranspiration,  
10 we had gone up to the point where you had  
11 described how in general terms you formulate  
12 the irrigation consumptive use or net irrigation  
13 requirement of a crop. What do you do after  
14 that?

15 A Okay. Just to refresh our minds, first we  
16 determined the potential evaporation, then  
17 we determined the crop consumptive use, and  
18 then we determined by subtracting the effective  
19 rainfall from the crop consumptive use, we  
20 determined the net irrigation requirement, or  
21 sometimes I call it irrigation consumptive  
22 use. Okay, so we are at this point.

23 If we add all the net irrigation require-  
24 ments for all the months in which the crop  
25 mesghinna-direct-clear



1 is planted --

2 Q All the months?

3 A During the months in which the crop is planted  
4 or started to use water up to maturity of the  
5 crop or harvest of the crop more or less, then  
6 that is really the total of all of these months  
7 is really the amount of water that the crop  
8 requests.

9 Q The crop itself requires?

10 A Yes. Okay, but the problem is if we apply the  
11 water or if we divert that water to the stream,  
12 the net irrigation requirement at the stream.  
13 All that water will not reach the point where  
14 we want. Some of it will be lost through  
15 seepage, some of it will be lost through  
16 leakage in the pipeline, and some of it, as  
17 we said, through deep percolation. Some of it  
18 is surface runoff, so we remain with very few  
19 water, which is not enough for the plant. So  
20 we have to correct this thing in order to get  
21 enough water at the site or at the fields.

22 In order to do this there are several  
23 things that have to be determined. One thing  
24 is we have to determine what is our efficiency

25 mesghinna-direct-clear

1 at the -- what is our efficiency or water use  
2 at the farm level. What is our efficiency  
3 between the farms and the pumps.  
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mesghinna-direct-clear

1 We call that distribution efficiency and another  
2 thing we have to consider is what is our efficiency  
3 between the pumps via the canal up the diversion  
4 structure. That is called conveyance efficiency  
5 and we have to determine that. And efficiency that  
6 we need at the farm level is called application  
7 efficiency or sometimes they call it on-farm efficiency.  
8 So prior to the determining the gross water requirement  
9 or water duty for that matter, we have to know this  
10 different irrigation efficiencies step by step.

11 Q You have to know how much water is lost before it  
12 gets to the plants?

13 A Yes. We have to do that. If we know the loss of  
14 water, then we have to add that loss of water to  
15 the necessary irrigation requirement, and then  
16 we divert that water.

17 Okay. This determination of efficiency in the  
18 field of irrigation is quite complex and it is not  
19 an easy method and there might be fewer field formulas  
20 here and there, but people have to use their judgment  
21 on it as much as they can. While I am here, it is  
22 important to note, I guess, that irrigation is not --  
23 the field of irrigation is not really a complete  
24 science. It is a combination of science and art,

25 mesghinna-direct=clear

1 more or less, so there are a lot of judgments that  
2 enter into the works of irrigation design, meaning  
3 scientific judgments. They are not judgments just  
4 from the -- (pause) Okay.

5 So our work is now to determine the application  
6 efficiency. After we find that efficiency, we deter-  
7 mine the distribution efficiency and then the convey-  
8 ance efficiency. After we determine all of those,  
9 there is what we call "overall efficiency". So that  
10 is a combination of these three efficiencies in a  
11 sense, in short mathematical, for overall efficiency  
12 is nothing but application efficiency times dis-  
13 tribution efficiency times conveyance efficiency.

14 THE SPECIAL MASTER: In that formula, do you  
15 apply the credit for return of detour to outlet  
16 or a credit for deep percolation of engine to outlet,  
17 or for --

18 THE WITNESS: In that formula we don't consider  
19 the water that can be used after it is outlet,  
20 because we believe that eventually that water is  
21 going to find its way in the streams back and can  
22 be used again. So really what we are trying to do  
23 is quantify the amount of water lost on the way  
24 coming from the diversion to the point of water use.

25 mesghinna-direct-clear



1 Now, before I go to determining the overall  
2 efficiency, now, we have some kind of perspective  
3 what we are looking for. I think it would be a  
4 better idea if we enter into the on-farm systems  
5 design, because while we are there we'll discuss  
6 the application efficiency.

7 THE SPECIAL MASTER: Let's do it.

8 THE WITNESS: Okay. I think that is easier.

9 MR. CLEAR: Yeah, you're the boss.

10 Q (By Mr. Clear) So let's go on to number four on  
11 farm systems design and can you explain what that  
12 is and what you did in relation to it?

13 A When I say "on-farms systems design" I am specifically  
14 talking to the fields themselves.

15 Q The fields?

16 A The fields, at the field level. I wish I could show  
17 in a map just what a field means, really.

18 Q Well, we have -- or we had --

19 ( At this time Mr. Echohawk and Mr. Clear moved  
20 a map to the board.)

21 Q (By Mr. Clear) On the top of the board I just put  
22 on the easel is Exhibit WRIR C-249. I don't want  
23 you to go into what that shows, but you wanted to  
24 show us what you meant by a "field". Is that useful

25 mesghinna-direct-clear

1 to you?

2 A Yeah. So people will have in their minds what I  
3 am talking about, so it's not in the abstract, I  
4 just want to show what a field is.

5 Q Use that and show us what you mean by a field.

6 MR..WHITE: Your Honor, I would like to inter-  
7 pose an objection if this is used for anything but  
8 illustrative purposes. This exhibit also falls  
9 outside of the ten day rule, or within the ten days.

10 THE SPECIAL MASTER: If this is used just for  
11 illustrative purposes, I'll overrule the objection.  
12 Go ahead.

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mesghinna-direct-clear

1 A Just to show what I mean by fields. As you see, we  
2 have different fields. For example, this is one  
3 field, this is the boundary by this area. This is  
4 another field. This is another field. This is  
5 another field. All those areas with the boundaries  
6 are fields. So each and every of this field has  
7 been studied by itself.

8 So when I say a field, I'm talking of one plot  
9 of land. For example, this is one field, you know.

10 THE SPECIAL MASTER: Yeah, one plot of land.

11 THE WITNESS: One plot of land.

12 THE SPECIAL MASTER: Yeah, very good.

13 THE WITNESS: That's what I mean.

14 Q (By Mr. Clear) Okay.

15 A Okay. When we talk on the on-farm systems design,  
16 what we're trying to do is we are trying to put  
17 together what we have learned so far. We have  
18 learned -- I mean, we have learned what climate  
19 is, what cropping pattern is, what evapotranspira-  
20 tion is. Okay, so all these things relate to the  
21 atmosphere and the plant water needs.

22 Okay, so we have to add into this other things,  
23 such as the soil. Okay, HKM has discussed the soil  
24 and we have to relate the plant and the soil. We

25 mesghinna - direct - clear

1 have to get it together -- we have to put it  
2 together. In a sense, what we will do is we will  
3 put together the relationship of the plant, the  
4 water and the soil.

5 Q Okay.

6 A Because these are the things that make up the  
7 yield.

8 Q Uh-huh.

9 A So, the important thing is to put all these things  
10 for each of the fields, the crop water requirements  
11 and the soil characteristics. Now, what are the  
12 most important things in terms of system design,  
13 crop characteristics? Well, the most important or  
14 a paramount important crop characteristic is the  
15 water-holding capacity of the soil.

16 Q Of the soil? Should we go back to your -- to that  
17 other drawing we had or --

18 A Okay.

19 Q -- to show what we're talking about?

20 A Yeah, we can do that.

21 Okay, we have studied the atmosphere in here  
22 as evapotranspiration and crop consumptive use, and  
23 now the plant is there and we want to relate the  
24 water that is to be absorbed in here later to be

25 mesghinna - direct - clear



1 used by the plants. Unless we know the capacity of  
2 the water to hold in here (indicating), we won't be  
3 able to define the plant. We won't be able to design  
4 our system. So we have to know. We have to quantify  
5 how much water is available, can be available, can be  
6 stored to be used by the plant in the subsurface of  
7 the soil.

8 The other thing of importance in this on-farm  
9 system design is the intake rate of the soil. The  
10 intake rate of the soil is nothing but the amount  
11 of water that enters into the soil that can perco-  
12 late into the soil per hour. In most cases it is --  
13 it's units or inches per hour.

14 THE SPECIAL MASTER: Is the term -- Yesterday  
15 we lived all day long with horizontal --

16 MR. WHITE: Do you mean hydraulic conductivity?

17 THE SPECIAL MASTER: Yeah, we talked about  
18 horizontal conductivity. Could this be vertical  
19 gravity hydraulic conductivity?

20 THE WITNESS: Yes, sir, you can call it more  
21 -- it is the vertical --

22 THE SPECIAL MASTER: Saturation or absorption?

23 THE WITNESS: Yeah, vertical entrance of water.  
24 The ability of the water to enter through the soil.

25 mesghinna - direct - clear

1 Let me give you an example. Let's take clay  
2 soil. Clay is a very tight soil, meaning that it  
3 is a very cohesive soil. The texture of the soil  
4 is held together and the soils are so fine in order  
5 for water to penetrate through it, it takes more  
6 time. However, if we have granular soil, which is  
7 soil like sand, and if we apply water into it, the  
8 water will be absorbed, enter quite easily as com-  
9 pared to clay.

10 So when we say intake rate of the soil, it is  
11 the ability of the soil to let water enter down in  
12 here.

13 THE SPECIAL MASTER: Does your science include  
14 the science and study of texture of soils to deter-  
15 mine that, too, or do you accept the other profes-  
16 sionals' judgment on that?

17 THE WITNESS: Well, we have to know the texture  
18 of the soil, and that is very important. And I will  
19 come to it --

20 THE SPECIAL MASTER: Okay.

21 THE WITNESS: -- later on.

22 THE SPECIAL MASTER: All right.

23 A. (Resumed) The other thing of importance in the  
24 on-farm system design besides water-holding capacity  
25 mesghinna - direct - clear

1 and intake rate is the root depths of the crop.  
2 What I mean by this is every crop has an ability  
3 to penetrate into the ground and take water from  
4 the ground. Some of them are very efficient. They  
5 can go down, way down, in the ground and take water,  
6 and some of them are not that efficient and they  
7 can't take water, only from the upper part of the  
8 soil.

9 To give you an example, for example, alfalfa  
10 can go deep as compared to, say, for example, small  
11 grain or pasture which have shallower root depths.  
12 So the soil depths should be related to the root  
13 depths of the plants.

14 Okay. So, now, I discussed about what water-  
15 holding capacity of the soil, I discussed about the  
16 intake rate of the soil, I discussed about the root  
17 depths of the soil, and I discussed earlier before  
18 the crop consumptive use of the plant. So we have  
19 defined really the immediate environment of the  
20 plant.

21 The next thing is we have to put these things  
22 together so as that they can be interrelated because  
23 one without the other cannot work.

24 Okay, just to give more explanation so as that

25 mesghinna - direct - clear



1 we'll have clear -- so that it will be clear in the  
2 minds of everyone: the higher the water capacity,  
3 the higher the water-holding capacity of the soil,  
4 the better the soil is. The reason for this is be-  
5 cause if -- what we're trying to say is if I can  
6 store more water in the root zone, if I can store  
7 more water in the root zone, then it will take me  
8 more days to irrigate (sic). I don't have to come  
9 every now and then and irrigate because there is  
10 water stored in the root zone in here. And on the  
11 other side, let's see what intake rate means. If  
12 the soil is very tight soil and water cannot pene-  
13 trate easily, what will happen is if I put more  
14 water into it, either there will be ponding or sur-  
15 face runoff or I have to change my management, and  
16 that is I have to put the crop -- I mean, I have to  
17 apply the water in very slow manner so as that most  
18 of the water can enter down into the soil.

19 So what we are trying to say is now we have to  
20 relate the intake rate of the soil with the sprinkler  
21 itself. Because if I bring a sprinkler that has a  
22 nozzle size, high size, it will apply water, the  
23 amount of water that I want per day. But most of  
24 the water might be lost.

25 mesghinna - direct - clear



1                    So what I have to do is I have to be careful  
2                    that I have to apply the water, if the soil is  
3                    tight, I have to apply the water in a small amount  
4                    so that -- to be sure that the water enters into  
5                    the ground. So these are the things that we want  
6                    to relate together.

7                    Okay, how do you determine water-holding capa-  
8                    city? First of all, water-holding capacity is mainly  
9                    a function of texture of the soil. So each soil, say,  
10                   sandy soil or clay soil or silt soil or gravelly soil  
11                   has a certain -- can hold a certain amount of water.  
12                   It can hold a certain amount of water in it.

13                   And how do we determine that each of these soils  
14                   can hold a certain amount of water? Well, this one  
15                   is -- a lot of work has been done on this and some  
16                   irrigation handbooks relate textures versus water-  
17                   holding capacity. And we used some handbooks, such  
18                   as Irrigation Handbook by Amos; secondly, we used  
19                   the Israelson and Hanson to a certain extent, which  
20                   is Irrigation Principles book from Utah State. We  
21                   also have used the water-holding capacity that has  
22                   been done in connection at the Midvale Irrigation  
23                   District, which is Soil Survey of Riverton.

24                   So, we put all these things together and we  
25                   mesghinna - direct - clear

1 came up with water-holding capacity versus texture  
2 and the same thing with intake rate. Okay, but what  
3 we know is only a certain texture can have a certain  
4 water-holding capacity. But the ground, the actual  
5 ground is not homogenous, it is not all clayey, it is  
6 not all sand or it is not all loam. It changes. It  
7 is heterogenous. So we have to determine the  
8 weighted average of the water-holding capacity in  
9 the ground.

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1 THE SPECIAL MASTER: For each plot of  
2 ground?

3 THE WITNESS: Yes, for each volume that  
4 we have, for each plot.

5 THE SPECIAL MASTER: For each plot?

6 THE WITNESS: Well, wherever there is a  
7 boring hole that has been --

8 THE SPECIAL MASTER: A bored hole?

9 Q (By Mr. Clear) Where did you get the bored  
10 holes?

11 A Yes, and HKM provides us with soil logs. We  
12 took their soil logs and we plotted them in  
13 our working plans, our working plans. After  
14 we did that we took each and every log that we  
15 can and we see on the soil profile what kind  
16 of soil textures are there, complete soil  
17 textures are there, then we determined the  
18 weighted water holding capacity. I think it  
19 would be a good idea if I can jot down what  
20 these water holding capacities ---

21 THE SPECIAL MASTER: Why don't you use  
22 the other half of the blackboard, if it's  
23 agreeable to Counsel. You can bring that  
24 exhibit down, too, if you wish. Okay.

25 mesghinna-direct-clear

1

(Brief pause.

2

THE SPECIAL MASTER: You can put it down.

3

I wish you would, in fact. That's better.

4

Just set it down anywhere.

5

THE WITNESS: Let's assume this is the

6

ground, ground surface.

7

(Whereupon, the witness  
(is drawing on the black-  
(board.

8

9

Here are the plants you're growing, and

10

here are roots, roots growing over here. Now,

11

let's assume there is a log here, blank log

12

that goes like this. Let's assume that the

13

soil has -- log has different soil textures.

14

And let's call, for simplicities sake, the first

15

part  $D_1$ , depths 1. It can be feet or feets,

16

whatever. The second one is  $D_2$ ; third one is

17

$D_3$ ; fourth,  $D_4$ . Okay. And I have stated earlier

18

that for each of the textures, since we know

19

the texture in here, we know the water holding

20

capacity for each of the textures. Let's call

21

this one water holding capacity  $_1$ , water holding

22

capacity  $_2$ , water holding capacity  $_3$ , water

23

holding capacity  $_4$ . We know the water holding

24

capacities for each of the stratum in here, but

25

mesghinna-direct-clear



1 we don't know the hole depths, so we have  
2 to devise a way on how to estimate this overall  
3 water holding capacity or average weighted water  
4 holding capacity.

5 We know these depths from here because it  
6 is in the log. For the time being I want to  
7 call this one (witness indicating) D weighted,  
8 D depths weighted total, weighted total.

9 THE SPECIAL MASTER: Weighted total depths?  
10 Weighted total.

11 THE WITNESS: Now, the overall water  
12 holding capacity that I have to discuss about,  
13 the whole thing in here is water holding capacity  
14 weighted of overall is equal to Depths <sub>1</sub> divided  
15 by water holding capacity <sub>1</sub> times total Depths,  
16  $DW_T$  plus the second Depths over the second water  
17 holding capacity times  $DW_T$ , plus the third Depths  
18 over water holding capacity <sub>3</sub> times  $DW_T$ , plus  
19 Depths <sub>4</sub> over water holding capacity <sub>4</sub> times  
20  $DW_2$  -- oh my God.

21 This is  $DW_T$  times water holding capacity <sub>1</sub>,  
22 (witness indicating),  $DW_T$  times water holding  
23 capacity <sub>2</sub>,  $DW_T$  times water holding capacity <sub>3</sub>,  
24  $DW_T$  times water holding capacity <sub>4</sub>. In a sense

25 mesghinna-direct-clear

1 what we are doing is the ratio of the water  
2 holding capacity of this one over all the  
3 depths is this (indicating), Depths <sub>1</sub> over total  
4 depths. Means that the proportion of water  
5 holding capacity of this depths is this times  
6 the water holding capacity <sub>1</sub>.

7 THE SPECIAL MASTER: Why can't you take  
8 finding the simplistic root of my moronic  
9 mind, which should go to add 1, 2, 3 and 4,  
10 getting the total of what, ten, and divide by  
11 four and come up with a two and a half of the  
12 weighted average for that area?

13 THE WITNESS: Okay, that would be good if  
14 all these are equal, all the depths are equal,  
15 but the depths are not equal. I mean, the  
16 strata of the soil are not, you know, made  
17 equally. Some of them are --

18 THE SPECIAL MASTER: Deeper?

19 THE WITNESS: The clay might be deeper,  
20 and sometimes the soil might be only a few  
21 inches or something of that sort. So in order  
22 to have a proportionate weighting water  
23 holding capacity we have to take into consideration  
24 what each soil strata represents in terms of

25 mesghinna-direct-clear

1 water holding capacity. So that's the reason  
2 we have to go through this long way.

3 THE SPECIAL MASTER: I see your numbers  
4 1, 2, 3 and 4 are just designations, they are  
5 not your results?

6 THE WITNESS: They are not. This might  
7 be only two depths, might be three depths,  
8 might only be one, or, I mean, only one soil  
9 all the way; it might be seven different kinds  
10 of soils. This is just to show the approach  
11 of the water. That's why I didn't put different  
12 depths -- I mean, two feet, one foot or something  
13 of this sort.

14 Okay, this is how we determined the water --  
15 weighted water holding capacity of a different --  
16 of a different soil log. That soil log, as you  
17 will see in the future, will present certain  
18 areas on the fields. Now, I said something about  
19  $DW_T$ . Now, let me stay here.

20  $DW_T$  is nothing but the weighted total of  
21 the crops. So  $DW_T$  is always about 4.5 feet.

22 MR. CLEAR: I think you -- explain in  
23 lay terms what the 4.5 feet is.

24 \* \* \* \* \*

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1 A Okay what I am trying to say about the formula,  
2 it is -- now we have 67 percent of alfalfa  
3 growing there in actuality as is proposed by  
4 the economist, and there is 12 percent of corn  
5 growing there and the rest is small grain. Now,  
6 if we come up with a weighted average of all  
7 the crops, there effective root depths, it will  
8 be 4.5. Say, for example, if alfalfa is five  
9 feet, let's assume -- let's say that, which  
10 is usually the case, alfalfa takes water up to  
11 depths of five feet down, and if we say corn  
12 takes water from 3 to 4 feet, and let's assume  
13 it is 3.5 feet and if we assume that small  
14 grain takes all the way from about 2.5 feet  
15 to about 3.5 or 3.75 feet, if we say on the  
16 average it consumes water from as deep as 3.25  
17 feet, and if we apply the porportion of this  
18 crop in pattern, if we multiply 67 percent by  
19 five feet, 12 percent by 3.5 feet, then whatever  
20 is left on the small grain, which is -- 16 plus 5  
21 in the lower areas -- 21 percent by 3.25, we'll  
22 come up with a weighted root depth of 4.5. So  
23 it is the weighted root depths of all the crops,  
24 you see. We have to combine them together.

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1 Q That's your weighted average root depths?

2 A That's the weighted average root depth.

3 Now, the question might arise that,  
4 "Hey, some of the logs are quite shallow as  
5 have been provided by HKM and some of them  
6 are deep, greater than 4.5 feet. What do you  
7 do on this problem?"

8 Okay. Let me go through the simplest  
9 one first. If it is greater than 4.5 feet,  
10 well and good. You assume if the plant can  
11 take water from the 4.5 feet, beyond that it  
12 can't take it. So if we have six feet of  
13 water, we don't say the plant takes from six  
14 feet down. It takes only up to 4.5 feet.

15 However, there is a problem that arises  
16 there. How do you know the rest of the stuff  
17 if the borings are shallower than 4.5 --

18 Q Let me see if I understand. If the boring was  
19 four and -- four and a half feet, you disregarded  
20 any information below four and a half feet?

21 A Yes, because the assumption that we have to  
22 make is the plant can take water only up to  
23 depths of 4.5 feet.

24 Q And everything below that is irrelevant?

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1 A As far as the plant is concerned. It's going  
2 to deep percolation or some sort. Okay.

3 You see, plants have -- they have some  
4 kind of mechanism. If the head is -- the head  
5 that they have to draw is too much for them,  
6 they can't take it, you know. So it can't take --  
7 we're saying that the plants on the average are  
8 not taking below 4.5 feet.

9 Q Now we go to the example with the HKM bore  
10 hole which did not go to 4.5 feet, and you're  
11 going to tell us what you did there to determine  
12 the water holding capacity?

13 A Okay, yes. Now, let's assume that for that matter  
14 we have only a log that says 12 inch --

15 THE SPECIAL MASTER: Says what?

16 THE WITNESS: Twelve inch.

17 THE SPECIAL MASTER: One foot.

18 A Just to make things easier, what do we do if  
19 this 12 inch -- you tell me that you need 4.5  
20 feet of root depths and how are we going to  
21 grow crop there? Okay.

22 So in order to answer this question, first  
23 what we do is we take the 12 inch, which is  
24 equal to one feet, so the water holding capacity

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1 total would equal that one feet which is 12  
2 inch of this one, over 12.5 feet, times the  
3 water from the capacity of that soil texture.  
4 What we do is if HKM gives or says that the  
5 soil below this is gravelly soil --

6 THE SPECIAL MASTER: What if they say the  
7 soil beyond that one foot is a barrier?

8 THE WITNESS: By definition the barrier  
9 is at six feet.

10 THE SPECIAL MASTER: You don't deal with  
11 barriers closer to the surface than six feet?

12 THE WITNESS: We will when it comes to  
13 drainage.

14 THE SPECIAL MASTER: Go back to your own  
15 definition, then. It's gravelly.

16 A Let's say gravelly or for some matter the  
17 driller quit his drilling from there, so what  
18 we are assuming, we assume the water holding  
19 capacity of the rest, 3.5 feet of gravelly soil.  
20 Gravelly soil has a very low water holding  
21 capacity, so what we are doing is we are  
22 punishing ourselves on the water holding capacity  
23 on the rest of the profile. What it means is  
24 that we are taking a conservative estimate,

25

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1 meaning we are saying that the soil can hold  
2 only very few water and as I have stated it  
3 earlier, if the water can hold a small amount  
4 of water, then you have to irrigate every now  
5 and then, which means more equipment, which  
6 means more cost on your investment. As we see  
7 it, later on this will be reflected in some  
8 of the units which have more of the sandy or  
9 gravelly soil, they have the higher costs.

10 THE SPECIAL MASTER: You would identify  
11 those as less efficient or more expensive?

12 THE WITNESS: More expensive, and even  
13 less efficient, yeah.

14 THE SPECIAL MASTER: Yeah.

15 A So what we do for the rest of this one, if they  
16 say gravelly, then we take all the way gravelly.  
17 The 3.5 feet would be gravelly soil, and when  
18 we say "Gravel" it's not pure gravel; it has  
19 some fine soils into it. It can hold a little  
20 amount of water. It can hold it but not as good  
21 as loam or clay or silt or even sand soil. So  
22 the rest, 3.5 feet, will be 3.5 feet over 4.5  
23 feet times the water holding capacity of that  
24 specific soil. So this is how we come up with

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1 the different kinds of soil depths that we  
2 have for all the areas where we have loss.

3 THE SPECIAL MASTER: Is the science so  
4 advanced that computer companies put out hand-  
5 held computers on which these formulas can  
6 be cranked out and get your answer, or do you  
7 just use a computer to do that?

8 THE WITNESS: This part of the area, one  
9 has to see each part of the soil, what they call  
10 the "Stratum" is a very painstaking job and  
11 it has to be done manually.

12 THE SPECIAL MASTER: By hand?

13 THE WITNESS: And people have to spend a  
14 lot of time going through this and putting  
15 together. But after we put all these things  
16 to analyze it, if one has to go through hand  
17 calculations, it will take him years and years  
18 probably to come up with what we are trying to  
19 show is efficiency and gross water application.  
20 So we have a completed program called on  
21 farm systems design program.

22 \* \* \* \* \*

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1 Q (By Mr. Clear) Can I ask you a question? Now, you  
2 were testifying about the weighted average holding  
3 capacity of the HKM logs. How many logs did you  
4 figure out the weighted average, weighted holding  
5 capacity for?

6 A Well, I can't exactly remember the number of logs.

7 Q Uh-huh.

8 A But we made sure that each field gets, you know,  
9 something. This does not mean that there are  
10 fields, some fields, which don't have, you know,  
11 logs of that kind.

12 Q Uh-huh.

13 A What we do is we go to the nearest point, to the  
14 nearest boring log and we apply that value.

15 Q What I asked, did you figure out the weighted hold-  
16 ing capacity for each and every log?

17 A For each and ever log.

18 Q Okay.

19 A In the North Crowheart there can be hundreds, you  
20 know, and we have to do that for each and every  
21 log. We have determined the water-holding capacity  
22 and the intake rate for all of these acres.

23 THE SPECIAL MASTER: You've been testifying  
24 about an hour. Do you want to take a little break?

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1 THE WITNESS: That would be very nice.

2 THE SPECIAL MASTER: All right, let's take a  
3 ten-minute recess.

4 (Recess, 1:56 p.m. to 2:10 p.m.)

5 THE SPECIAL MASTER: Shall we come to order,  
6 please.

7 Proceed, Mr. Clear.

8 Q (By Mr. Clear) All right. Are we still on water-  
9 holding capacity?

10 MR. WHITE: I think we are on the computer.

11 A. I think we beat it to death now. So --

12 Q (By Mr. Clear) Okay.

13 A. And if needed so, we'll come back later on and it  
14 will enter into other things and we'll relate it  
15 with the other things.

16 Q Uh-huh. Okay. Now, you have determined the weighted  
17 water-holding capacity for each hole and the intake  
18 rate for each hole. What did you do with that infor-  
19 mation?

20 A. Okay. Now, we determined this soil characteristic  
21 data and we have to relate it with the plant and the  
22 crop consumptive use.

23 Q Uh-huh.

24 A. And how do we do that? Okay, first, what we have to

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1 do is we have to transfer this data to our working  
2 maps.

3 Q Uh-huh.

4 A When we transfer it there, there will be the water-  
5 logging capacity and the intake rate and the other  
6 necessary things.

7 Q Uh-huh.

8 A From that then we make a layout of the fields.

9 Q Uh-huh. Like those total units you pointed out on  
10 the --

11 A Yes, the fields that I pointed out before.

12 Q Right.

13 A Okay.

14 THE SPECIAL MASTER: Which we have called plots,  
15 we have called them fields and we have called them  
16 tracts. And should we make one word for --

17 MR. CLEAR: We were calling them on-farm systems  
18 design. Should we call them fields?

19 THE SPECIAL MASTER: Yeah. Well, that's not  
20 literally or figuratively true.

21 MR. WHITE: We would stipulate to "field",  
22 Your Honor.

23 THE SPECIAL MASTER: All right, let's use  
24 "field" from now on, "field" from now on for the

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1 one word.

2 THE WITNESS: Okay.

3 A. So we transferred the data in each of the fields,  
4 and what we have to do is now we have the boundaries  
5 of the irrigable lands.

6 THE REPORTER: I'm sorry.

7 THE WITNESS: The irrigable lands --

8 THE SPECIAL MASTER: Irrigable.

9 A. -- from HKM and that is also transferred into our  
10 working map.

11 MR. WHITE: Your Honor, I would move to strike  
12 the answer because the HKM data which is in evidence  
13 all relates to arable.

14 THE SPECIAL MASTER: I was about to --

15 Do you mean arable?

16 THE WITNESS: I mean arable.

17 THE SPECIAL MASTER: Not irrigable, but arable.

18 That is my fault, Lamont, not yours. I tried to  
19 prompt the reporter and I loused it up.

20 Okay. Okay. Arable.

21 A. On the arable lands one thing that we have to be  
22 careful in putting the fields there is we don't  
23 just put the field because it looks nice this way  
24 and it looks better that way and so on. We have

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1 to consider some things as to topography of the  
2 field as to the slope of the field and so on. And  
3 we try to put as much as we can -- this is not al-  
4 ways true -- as much as we can we plot the fields  
5 so that the sprinkler lateral, the lateral lines  
6 will be on slope parallel with the slope of the  
7 land.

8 Q (By Mr. Clear) Uh-huh.

9 A. Okay. Then after that, after we plotted each field,  
10 we try to see the dimensions of the field, meaning  
11 the length of the field and the width of the field.  
12 This field, when we put the field, it took us a long  
13 time and there has been several changes. You know,  
14 we improve it every now and then until we think we  
15 are near perfection. Of course, we started with  
16 84,000 acres of arable land and we have cut it down  
17 to less than 54,000. This is due to sometimes leav-  
18 ing areas when we square off --

19 Q Uh-huh.

20 A. Sometimes mainly too high to irrigate it and, you  
21 know, that kind of makes sense.

22 THE SPECIAL MASTER: Just a moment, please.

23 Will the reporter please go back and read that to  
24 me, the figures on arable lands reduced to certain

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1 arable lands?

2 (The above portion of the  
3 (answer was read back by the  
4 (reporter as follows; "-- we  
5 (started with 84,000 acres of  
6 (arable land and we have cut  
7 (it down to less than 54,000.  
8 (This is due to sometimes leav-  
9 (ing areas when we square off --"

10 THE SPECIAL MASTER: Go ahead, Mr. Clear.

11 Q (By Mr. Clear) Dr. Mesghinna, you mentioned just  
12 a little while ago in laying out your fields, you  
13 tried to lay them out parallel to the contours be-  
14 cause of slope, is that --

15 A Yeah, because we want to have the laterals to be  
16 as level as we can as much as possible, although  
17 in sprinkler irrigation that's not necessary. But  
18 it will be better if it is as level as can be. So  
19 if we put it parallel with the contour, then there's  
20 not much change in the, you know, the differences  
21 of slope between the beginning of the lateral and  
22 the end of the lateral. The beginning of the lateral  
23 is here (indicating) and the end of the lateral is  
24 here. So we don't want to have --

25 Q Excuse me, I thought you were pointing to an exhibit  
I have just put up. It is United States WRIR C-247,  
which is another one of the illustrations --

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1 THE SPECIAL MASTER: Entitled, "Side Roll".

2 MR. CLEAR: Entitled, "Side Roll".

3 A. So we'll try -- what we are trying to do is we are  
4 trying to, if the contour is going like this (indi-  
5 cating), we'll try to put it with the contour as  
6 much as we can, but this is not necessarily true in  
7 all cases. If we cannot do that, then we have to  
8 go the other way, you know.

9 Q (By Mr. Clear) Uh-huh. What's the -- Do you have  
10 a limit on the amount of slope in a field or did  
11 you --

12 A. Well, as you probably know, according to the soil  
13 classification, the maximum you can go is 20 percent  
14 slope, 20 percent slope. But as to my recollection,  
15 I don't think we have greater than between 10 and  
16 15 percent. We have eliminated as much as possible  
17 those areas that have high slopes.

18 THE SPECIAL MASTER: Of your total acreage  
19 that you're going to recommend, how much of that  
20 would be between 10 and 15, relatively little?

21 A. A very, very small, extremely small, probably, oh,  
22 this is just approximately, I mean just -- probably  
23 10 percent or 5 percent, something of that sort.

24 Well, in order to have a better understanding of

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1 what we're discussing, this is the canal as we can  
2 see it and this is a pumping station. It is taking  
3 water from the canal. And this is called a distri-  
4 bution line, the line that goes from here, which I'm  
5 going to discuss later on in detail, and this line  
6 is called on-farm mainline.

7 THE SPECIAL MASTER: On-farm mainline?

8 THE WITNESS: Yeah, or field mainline.

9 THE SPECIAL MASTER: Uh-huh.

10 THE WITNESS: Let's call it field main line.

11 THE SPECIAL MASTER: What distinctions are  
12 made as to whether those are lined or unlined or  
13 what action has been taken to conserve loss of  
14 water in a distribution -- Did you deal with those  
15 factors?

16 THE WITNESS: Yeah. I'm going to discuss  
17 about them later on.

18 THE SPECIAL MASTER: All right, then I'll  
19 wait.

20 A. Okay. So we have the canal, we have the distribu-  
21 tion line, we have the farm main line and then the  
22 -- and the lateral is connected with the farm main  
23 line. So when I say "lateral", I'm talking the  
24 sprinkler, including the pipes that have the sprinklers

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1 and the wheel of the lateral, this (indicating) and  
2 plus the drive unit. That's what I mean by lateral.  
3 So the drive unit is the unit, the motor that drives  
4 it.

5 THE SPECIAL MASTER: Yeah. Yeah.

6 A. Okay.

7 Q. (By Mr. Clear) Actually you're --

8 THE SPECIAL MASTER: Are we on No. 5? Did we  
9 just sort of naturally gravitate to it?

10 MR. CLEAR: Not quite. We are still on the  
11 farm systems.

12 THE SPECIAL MASTER: We are still on farm  
13 systems?

14 Q. (By Mr. Clear) I think maybe, Dr. Mesghinna, you  
15 ought to just explain the difference. Can you  
16 explain it in that 247, the difference between the  
17 pipe system and the on-farm system?

18 A. Oh, when we talk of on-farm system, really, we're  
19 only dealing with this.

20 THE SPECIAL MASTER: I see,

21 A. And what you call the joints. Other than that --  
22 the valves, I mean the valves and also the sprinkler  
23 lateral.

24 THE SPECIAL MASTER: Lateral.

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1 THE WITNESS: That is the on-farm system.

2 A. I haven't touched anything that relates to the dis-  
3 tribution line or field main line or canal or any-  
4 thing so far.

5 THE SPECIAL MASTER: I see. I see.

6 A. So I'm only talking now in here because from here  
7 we'll move to here, from here we'll move to here  
8 (witness indicating several times) and so on to  
9 here and then to here and so on.

10 THE SPECIAL MASTER: Yeah, as we go on down  
11 the line.

12 Q. (By Mr. Clear) Well, now, you have laid out the  
13 farm or you have laid out the farms --

14 A. Uh-huh.

15 Q. -- or fields. And I suppose now we are trying to  
16 figure out the sprinkling system we need or the  
17 irrigation system, is that right?

18 A. Uh-huh.

19 Q. All right.

20 A. Okay.

21 Now, that we have put the necessary data in  
22 order to design our system, on-farm systems design,  
23 then we can go ahead and find out what are the  
24 necessary things that enter into it. Okay. Now,

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1 we know --

2 Q I think you're going to have to speak a little  
3 louder.

4 A. Okay, we know our water-holding capacity and we  
5 know our root depths and sizes of our fields, and  
6 now we are ready to crank on and relate the crop,  
7 meaning the plant, the soil characteristics and  
8 the crop water requirements.

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1 THE WITNESS: Okay. But I have to define  
2 certain things before I do that, and that is  
3 net depths of irrigation.

4 THE SPECIAL MASTER: Net depth of  
5 irrigation?

6 THE WITNESS: Yes, net depths of irrigation  
7 is the amount of water, the net amount of water  
8 that we apply at a given irrigation time. I  
9 will define it this way: Net depths of  
10 irrigation is equal to the water holding capacity  
11 times the root depths times depletions.

12 THE SPECIAL MASTER: What was the last  
13 item?

14 THE WITNESS: Depletion.

15 Q (By Mr. Clear) Well, we have the water  
16 holding capacity and we have the root depth.  
17 Explain what depletion is, then we'll have all  
18 three elements.

19 A Okay. Depletion is nothing but -- it is the  
20 amount of water that is to be used by the  
21 plants between irrigations. If we irrigate  
22 today in one spot and we come back and we  
23 irrigate -- we come back after 12 days, it is  
24 the amount of water that has been depleted

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1 between this 12 days.

2 Let me explain it really more because  
3 it's a very important thing. When I say  
4 water holding capacity, I mean water holding  
5 capacity inch per foot. So the water holding  
6 capacity inch per foot multiplied by the  
7 total depths, which is 4.5, will give us  
8 the total amount of water that can be  
9 stored in the soil surface, the total  
10 amount of water that can be stored in the  
11 soil surface.

12 The soil surface has two limits: One  
13 is called field capacity.

14 THE SPECIAL MASTER: Field to capacity?

15 THE WITNESS: Yes, field capacity.

16 THE SPECIAL MASTER: Field capacity?

17 THE WITNESS: Field capacity.

18 Q (By Mr. Clear) Filter or field?

19 A Field.

20 Q Field?

21 A Yes, field, field capacity, and the other  
22 limitation is called wilting point.

23 Q Wilting point?

24 A Wilting point. Now, let me define it more.

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1 Field capacity is the capacity -- it is the  
2 amount of water that is stored when the soil  
3 has enough water, is filled with water. That  
4 doesn't mean saturation, it is not saturated  
5 with water. There is some air to it. It is  
6 usually, you know, when we talk about an  
7 irrigation, it is usually -- the amount of  
8 water stored in a given field after irrigating  
9 it, 24 hours after irrigating it, then if you  
10 go in and measure that amount of water in  
11 that field, that is field capacity.

12 THE SPECIAL MASTER: Twenty-four hours  
13 after completing irrigation?

14 THE WITNESS: Yes, after we apply water,  
15 because what happens is at -- in saturation  
16 there is gravity flow going down, but at field  
17 capacity gravity flow ceases, there is no  
18 gravity flow, the water is there, it's available  
19 for the plant.

20 Okay, the other limit that I brought up  
21 is the wilting point. The wilting point is  
22 the amount of water left in the soil at which  
23 the plant can no longer -- can no longer take  
24 water, but dies. It dies, the plant starts to

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1 die.

2 THE SPECIAL MASTER: Because there is  
3 simply no longer any water to take?

4 THE WITNESS: There's no water there, it  
5 can't take -- it can't suck water from the root  
6 zone. So that is called the wilting point.

7 Okay, so if we see in a sense really the  
8 difference between field capacity and wilting  
9 point, that is the total amount of water  
10 available in the root zone. But, should we  
11 wait until the plant uses all this water --

12 THE SPECIAL MASTER: You are not going to  
13 be a very good farmer.

14 THE WITNESS: You are not going to be a  
15 very good farmer. So we have to give some  
16 allowance, and in this case we gave it a  
17 generous allowance. We have said -- we have  
18 assumed that our depletion will be only 50  
19 percent. What it means is when 50 percent  
20 of the water is finished by the plant,  
21 irrigation, add water, don't wait below that.

22 Q (By Mr. Clear) If you wait below that you --

23 A Well, for plants like alfalfa, you can go way  
24 down than 50 percent, you can go 60 or even more

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1 than that, and still the plant will be in good  
2 shape. But there are crops that are very  
3 sensitive crops like potatoes, and you need  
4 to apply water every now and then because they're  
5 sensitive crops. We call them sensitive crops.  
6 They are not stress resistant, they don't have  
7 the resistance of stress of water.

8 But crops like alfalfa, I think alfalfa  
9 is one of the easiest crops to manage than any  
10 other crop because it's --

11 THE SPECIAL MASTER: Do you know offhand  
12 if the sugar beet is also stress resistant or  
13 can it take a dry spell, the sugar beet?

14 THE WITNESS: Sugar beet, I will say it's  
15 medium as much as anything, so alfalfa is easy  
16 to manage really because if a farmer cannot do  
17 good in alfalfa, he cannot do good in other crops.

18 Q (By Mr. Clear) So we have the depletion set  
19 at 50 percent?

20 A Yes. We could have set it more than 50 percent,  
21 but it would be more conservative. It would  
22 cost more, you know, if you set it 50 percent  
23 rather than 60 percent. But it's better to be  
24 on the safe side. But at any rate, in our design

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1 it is at least 50 percent. In many cases  
2 it's not even 50 percent because when you  
3 adjust all those intake rates and so on and  
4 so on, it makes it harder to hit on 50 percent,  
5 you have to be less than 50 percent because  
6 if the intake rate is low, meaning that the  
7 water cannot take the water anymore, cannot  
8 enter anymore, so you have to look for a lower  
9 depletion, you know, to satisfy the plant so --  
10 which means you have to irrigate it frequently.

11 Q Okay.

12 A Okay.

13 Q So by using the weighted water holding capacity  
14 and the root depths times the depletion  
15 allowance, we have come up with the net depth  
16 of irrigation?

17 A Yeah. We determined the net depths of irrigation  
18 for each field. We are talking -- when we talk  
19 of fields, just to give you some magnitude,  
20 we are talking about like 300 fields just in  
21 the Diversion Dam area, in the Diversion Dam  
22 climatic zone of North Crowheart.

23 Q All right.

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1 A We have to go through each of these in the net  
2 depths of irrigation. After we determine the net  
3 depths of irrigation, what we are saying is we need,  
4 the plant needs this amount of water between irri-  
5 gations. But that does not mean you have to apply  
6 that amount of water to the plant. You need more  
7 water to apply to it, because there are some avoid-  
8 able and unavoidable water losses and that is where  
9 the application efficiency comes.

10 I have stated earlier that I would discuss  
11 the application efficiency when it is -- when it  
12 is related to the things I am discussing, so I think  
13 I can go ahead and discuss it, because now we are  
14 in the net depths of irrigation, we want to deter-  
15 mine the gross depths of irrigation, so we need to  
16 know the application efficiency.

17 Efficiencies are hard to compute. They are  
18 probably one of the hardest things, and people  
19 use certain amount of application efficiency and  
20 they go -- they say 50%, 40%, 30%, even 70, 80%,  
21 and so on. But there are some guidelines to come  
22 up with application efficiency. Application  
23 efficiency is mainly a function of net depths  
24 irrigation.

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1 Q Which we just figured that out.

2 A We just figured that out, and the wind speed.  
3 The reason why wind enters is because when you  
4 apply water in a sprinkler, the wind can deflect  
5 the water application and give you a different  
6 uniformity of the irrigation application and the  
7 uniformity of irrigation also affects application  
8 efficiency. So that has to enter into play in  
9 sprinkler irrigation.

10 The determination of application efficiency --  
11 the other parameter that is important in determination  
12 of application efficiency is peak consumptive use --

13 Q Peak?

14 A Peak consumptive use, p-e-a-k, consumptive use of  
15 the crop. Peak consumptive use is nothing but the  
16 consumptive use, the peak consumptive use, during  
17 the warmest months or during the time when it is  
18 at its peak, and that is determined by soil conser-  
19 vation method which is a standard formula in the  
20 Technical Release No. 21.

21 Q Okay.

22 A So we have the peak crop consumptive use, we have  
23 the net depths irrigation, and we ought to say  
24 something about the wind speed.

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1 Wind speed is hard to get as data. People  
2 assume certain wind speeds and so on, but we found  
3 some wind data in the Riverton area that has been  
4 done from 1967 until 1971 and for each month, and  
5 we determined those. What you call "wind speed" --  
6 wind speed is not really very critical in this deter-  
7 mination of application efficiency because --

8 THE SPECIAL MASTER: A statement like that  
9 will make you very popular in Wyoming. Wind speed  
10 is not very critical.

11 A Yeah, what I mean is you don't have to know the  
12 exact wind speed is 4.5 miles per hour or 6.2.  
13 What you have to know is the range of wind speed  
14 from 0 to 4.

15 THE SPECIAL MASTER: Oh, the gusts?

16 THE WITNESS: No, miles per hour. The wind  
17 speed in miles per hour.

18 THE SPECIAL MASTER: Oh, the rate. Wind  
19 speed in miles per hour.

20 THE WITNESS: Yes. That's what you need to  
21 know, and that should not necessarily be -- we  
22 shouldn't necessarily be exact in knowing that.

23 What is needed is from 0 to 4 miles per hour,  
24 it will get a certain amount of application efficiency.

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1 From 4 to 10 miles per hour it will give us certain  
2 amount of application efficiency.

3 THE SPECIAL MASTER: How do you measure a wind  
4 that gusts from 1 to 2 to 15 in the course of an  
5 hour, and can gust 25 times in an hour? That is  
6 variable winds are gusting.

7 THE WITNESS: Yes.

8 THE SPECIAL MASTER: What does that do to  
9 sprinkler efficiency?

10 THE WITNESS: What we have to do is for that  
11 kind of different speeds we have to find the fre-  
12 quency at which these wind speeds are coming. Say,  
13 for example, 10 to 15 miles per hour, it might come  
14 10 times per day, so we have to know this.

15 THE SPECIAL MASTER: Then what do you do with  
16 that?

17 THE WITNESS: Average it out for the month.

18 THE SPECIAL MASTER: I see.

19 THE WITNESS: And then we determine at what  
20 stage -- at what range we are from 0 to 4, 4 to 10,  
21 or greater than 10. That's the only thing necessary  
22 in this application efficiency.

23 So after we enter the, what you call wind  
24 speeds, net depths of irrigation, and peak consumptive  
25 mesghinna-direct-clear

1 use, then we can find the application efficiency  
2 from handbook --

3 THE REPORTER: Pardon me?

4 A -- from handbook, which is Irrigation Handbook by  
5 Amos. However, in doing this, as I have stated it  
6 earlier, in connection with the overall on-farm  
7 system design we have a computer program that  
8 scans through all this and finds the application  
9 efficiency. Okay.

10 Okay, now, we know the application efficiency.  
11 Where do we use it? So if we divide the net depths  
12 of irrigation by the application efficiency, then  
13 we determine the gross depths of irrigation. Gross  
14 depths of irrigation is nothing but the amount of  
15 water that the farmer should apply on his field during  
16 a given day.

17 Q (By Mr. Clear) That's --

18 THE SPECIAL MASTER: A farmer should apply  
19 on his field in any given day?

20 THE WITNESS: Yes, in any, you know, and the  
21 management schedule that we have is the sprinklers  
22 will move twice a day. We'll put the sprinkler  
23 at one position for about half a day and then we  
24 come in the evening and we move it to another

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1 position and then we come back the next day and  
2 move it to another position and so on.

3 So during the time -- during that time, about  
4 half a day, the gross depths of application should  
5 be applied in that land which is only 60 feet in  
6 size.

7 THE SPECIAL MASTER: Uh-huh. Yes, Mr. Clear,  
8 go ahead.

9 Q (By Mr. Clear) For example, suppose we said we  
10 had an application efficiency of 50%. What does  
11 that mean in amount of water you have to apply?

12 A Okay.

13 Q Maybe 50% is not very good. Let's say 55% so we  
14 know what it means.

15 A Well, I will choose the 50% in order to make things  
16 easier for everyone.

17 Let's say that we determined the net depths  
18 of irrigation, which the water holding capacity  
19 times depths times depletion, it's two inch for  
20 that month to make things easier, so the gross  
21 depths of irrigation will net depths of irrigation  
22 divided by the application efficiency, which means  
23 that two inch divided by 50%. So the farmer should  
24 apply four inch of water -- four inch of water is

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1 this high (indicating) -- which means he had to  
2 apply during those about 12 hours he should apply  
3 about four inch of water in order for the ground  
4 to be at fill capacity. In order for the ground  
5 to be filled with the water necessary for the  
6 plant.

7 Q So basically he would have to apply four inches of  
8 water to get two inches into the ground?

9 A Exactly. The other water either goes to surface  
10 run off or deep percolation or might even evaporate  
11 while the sprinkler is running, you know.

12 THE SPECIAL MASTER: Yes.

13 A So that is what I am calling gross depths of irri-  
14 gation, and that is the place where the application  
15 efficiency enters.

16 Q All right.

17 A Okay.

18 THE SPECIAL MASTER: Now, we're ready for a  
19 pipe network system?

20 MR. CLEAR: Just about there. There is one  
21 more area to cover, right?

22 THE WITNESS: I think we will have more.

23 THE SPECIAL MASTER: Well, I am not trying  
24 to gloss over anything substantive; I am trying to  
25 mesghinna-direct-clear

1 respect our goals of moving along.

2 MR. CLEAR: I think we are actually. We've  
3 been on less than a day, Your Honor. This trial  
4 has been on several months, and this is very im-  
5 portant testimony, Your Honor.

6 THE SPECIAL MASTER: Fine, no problem.

7 THE WITNESS: One thing is after we finish  
8 this thing, things will be easier. We have laid  
9 the foundation of everything and things will move  
10 fast.

11 THE SPECIAL MASTER: Certainly.

12 MR. CLEAR: After we get past this one.

13 THE WITNESS: If we finish number four, things  
14 will be easier. We take the rules from number four  
15 and apply it to the others, and it will be easier.

16 THE SPECIAL MASTER: I think this is probably  
17 the most crucial of all ten. It's so complex you  
18 can't get any more facts into it.

19 THE WITNESS: Okay.

20 A Now, the next thing is what we call the "irrigation  
21 frequency" -- every how many days do we have to  
22 irrigate. That is what irrigation frequency means.  
23 Okay.

24 The irrigation frequency is nothing but the  
25 mesghinna-direct-clear

1 net depths of irrigation divided by the peak con-  
2 sumptive use. Peak consumptive use is namely in  
3 terms of inch per day -- inch per day.  
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1 Q (By Mr. Clear) Right.

2 A Okay. So, if we say we need 2 inches of water as  
3 a net depth of water, of the net depth of water,  
4 2 inches of water, and let's assume for simplicity  
5 sake that the peak consumptive use is .2 inches  
6 per day --

7 Q This is the consumptive use is the amount of water  
8 the plant takes, right?

9 A The plant takes at its peak time during its peak  
10 time.

11 Q Uh-huh.

12 A Then the irrigation frequency will be 2 inches  
13 divided by .2, you know, net depths of irrigation  
14 divided by the peak use, because it will take it  
15 10 days in order for the plant to finish that half  
16 part which is 50 percent of the soil reserve. So  
17 what it means is the farmer should come back again  
18 and irrigate that land after 10 days.

19 Q Uh-huh.

20 A And in reality, however, this does not happen.  
21 Probably it happens only once because the peak  
22 consumptive use, there's no peak consumptive use  
23 except at one time. You know, the rest of the  
24 time in May, April and September it's cool and

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1 you don't irrigate every now and then. Most -- a  
2 substantial amount of your sprinklers will be idle,  
3 standing there. You need all of them only during  
4 one time, during the peak season.

5 Q Uh-huh.

6 A Okay. So after we determined the irrigation fre-  
7 quency then, now we are ready to determine the num-  
8 ber of sprinklers needed to -- the number of laterals  
9 needed for a given field.

10 Q Before we go on to that, I did ask you about the  
11 slope before with relation to the farm design system.  
12 I haven't asked you about -- I think what's taken in  
13 much time of the trial heretofore is the classes of  
14 lands established by HKM. They have those Class 1,  
15 2, 3 and 4. Are you familiar with those?

16 A Yes.

17 Q How do they fit into your on-farm or field system?

18 A You know, different classes of soil are due to dif-  
19 ferent reasons. The soil is of lower class, probably  
20 because it has a high slope, or it might have topo-  
21 graphy that is not too good, or it might have drain-  
22 age problems. You know, things of this sort. But  
23 when we do the on-farm system design, we are looking  
24 at each and every boring hole.

25 mesghinna - direct - clear

1 Q Uh-huh.

2 A And when it is a slope, we don't have much limita-  
3 tion in sprinkler irrigation. So that thing comes  
4 out. When it is drainage, we take care of the  
5 drainage problem in our drainage analysis and that  
6 comes out. The other things, say, for example, it  
7 has lower water-holding capacity or its intake rate  
8 might be low or something of this sort.

9 Q Uh-huh.

10 A So what we do is we are taking care -- taking that  
11 one into consideration, as I have explained it  
12 earlier.

13 Q Uh-huh.

14 A So it means we are examining it in a more detailed  
15 manner. Where does all this reflect? All these  
16 things will reflect in the cost. If you have an  
17 area that has less water-holding capacity, you have  
18 to irrigate it every now and then, which means you  
19 need more laterals.

20 Q Uh-huh.

21 A So you have more costs. Let's say, for example,  
22 just to cite one example, if we say Riverton East  
23 Unit. The classes of soils in that unit are mainly  
24 Class 3 and Class 2 soils. There's no Class 1, as

25 mesghinna - direct - clear

1 I remember it in that unit. So what happens is the  
2 cost of your on-farm system gets higher. You need  
3 more laterals per unit acre. So all these classes  
4 will be reflected in our cost estimate and in your  
5 management and in the amount of facilities you need  
6 in the irrigation system design.

7 Q All right. So we are back now, I guess, determining  
8 the number of laterals and actually designing this  
9 system, is that where we are or --

10 A Yeah.

11 Okay. The next thing we need to know is we  
12 need to know about money. Okay, we have the crop.  
13 We studied the climate. We know the crop water use.  
14 We found out the soil characteristics and the mechan-  
15 isms and so on, how the water is going to be taken.  
16 All these things have been studied. What does it  
17 take to apply the water to the farm? How much does  
18 it cost? So we have to determine the number of  
19 laterals needed in each of the units.

20 Q Each of the fields?

21 A Yeah. Then we added up to each pump station.  
22 Then we added up in the unit as a whole.

23 Q Yeah.

24 MR. CLEAR: Do you want a glass of water or  
25 mesghinna - direct - clear

1 something?

2 A The number of laterals is estimated in the following  
3 way: We have a field this long (indicating). One  
4 lateral covers 60 feet per irrigation.

5 Q Uh-huh.

6 A So that lateral covers, since we move it twice, it  
7 covers 120 feet per day. If there's 1,440-feet  
8 long field, how many days will it take to cover it?  
9 It is 120 -- I mean, 1,440 feet long divided by  
10 1,440 feet (sic). This is the number of days.  
11 So, if, instead of doing that, I know the irriga-  
12 tion frequency, let's say it is 10 --

13 Q Uh-huh.

14 A And I multiply and I have the one lateral moves 120  
15 feet per day. So in 10 days it will cover 1,200 feet.  
16 But my field is 1,440 feet. So I need one lateral in  
17 it and a little more than a lateral.

18 Q Uh-huh.

19 A So the number of laterals is nothing but the field  
20 length divided by the amount -- I mean, the length  
21 of feet covered per day by each lateral multiplied  
22 by the irrigation frequency.

23 Okay, so we go on like this and the computer  
24 determines the number of laterals. But what do we do

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1 because the computer cannot distinguish between  
2 land that is perfectly square or perfectly rectan-  
3 gular. It can't see a rectangular or square field  
4 and so on. It can't see it because, you know, there  
5 are fields that are something like trapezoidal shape  
6 or, what shall I say, somehow triangular shape.

7 THE SPECIAL MASTER: Semicircles, triangles,  
8 obtuse triangles --

9 THE WITNESS: Uh-huh.

10 A. So what we have to do is after we take out that from  
11 the computer program, then we have to take all those  
12 fields, all those outputs, and go by hand each and  
13 every field and determine what is the maximum size  
14 of laterals needed, lateral lengths needed.

15 Q. (By Mr. Clear) Now, when you're talking about the  
16 number of laterals, the maximum number of laterals,  
17 you're talking about during the time of peak con-  
18 sumptive use?

19 A. Yes, this is only during the peak consumptive use.  
20 If we need, for example, in a certain field three  
21 laterals, that is only during very few days.

22 Q. Uh-huh.

23 A. After that some of the laterals will be idle, you  
24 know, or they have not much to do because they are --

25 mesghinna - direct - clear

1 the temperature is low or -- I mean, the demand for  
2 water is low, so we don't need those laterals. So  
3 we use less laterals after that.

4 Q But even though they are only used a few times, you  
5 still have to go out and buy them?

6 A You have to buy them. That is very necessary if  
7 you have to get optimum yield.

8 So, after taking out from the computer, and  
9 then we go each field by field and see how many  
10 laterals are, indeed, necessary if we have this  
11 triangular shaped field. The computer will give  
12 us an average size of lateral.

13 I think -- Let me put this -- this might help,  
14 on the blackboard.

15 MR. CLEAR: Let me take this down.

16 THE SPECIAL MASTER: Do you want to erase that  
17 portion? Why don't you?

18 THE WITNESS: Okay.

19 THE SPECIAL MASTER: But leave the listing,  
20 won't you?

21 THE WITNESS: Yeah, I'll leave those.

22 A If it so happens that-- Let's take the worst kind  
23 of field that looks something like this (witness  
24 drawing). We have the farm main line here and we

25 mesghinna - direct - clear

1 have the laterals going like this (indicating).  
2 Now, the problem is what do you -- what the com-  
3 puter does. It takes an average field size, pro-  
4 bably somewhere in this area. You have a lateral  
5 and it gives you that lateral size. But if I use  
6 this lateral, it might help me to, you know, irri-  
7 gate this area on this lateral by cutting some of  
8 the sprinklers as I go along this way (indicating).  
9 But it won't be useful this way because it is short.  
10 If I use it this way, it will irrigate only this  
11 area, it won't be able to irrigate this area in  
12 here. So what we do is we go take the computer  
13 output and we take the maximum size lateral, and  
14 if this lateral requires two laterals, then we  
15 have to buy those laterals that are maximum in  
16 length, although we don't need them, because some  
17 of the sprinklers in the laterals will be taken  
18 out as we go along the way. But that is only  
19 tough luck.

20 So we have to buy those laterals, although  
21 it costs more, to satisfy the irrigation. So  
22 that's what I meant when I say we have to adjust  
23 the lateral size by hand.

24 So after we determine the number of laterals,

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1 after we determine the number of laterals required  
2 in each of the fields, then we go to each pump  
3 station. I'm not going to discuss about pump  
4 station, I'll discuss only in relation to the num-  
5 ber of laterals in a given pump station.

6 Say, there are almost -- let's say there are  
7 59 pump stations in the North Crowheart.

8 THE SPECIAL MASTER: North Crowheart?

9 THE WITNESS: Yeah.

10 A And our assumption there is that within a given  
11 pump station, within a given pump station we can  
12 exchange laterals, but we cannot exchange laterals  
13 from one field to another field outside of a given  
14 pump station. Okay, what I mean is if in one place,  
15 in one field we need five laterals --

16 Q (By Mr. Clear) Uh-huh.

17 A -- and we are short of a lateral in another field,  
18 then we can move one lateral from one field to  
19 another field to cover that field. Okay, but that  
20 is only applicable in a given pump station. It  
21 can't get out of that because we believe it will  
22 be too long to transport it. You know, the laterals  
23 and so we can only do this within a given pump  
24 station.

25 mesghinna - direct - clear



1                    So in that way we determine the number of  
2                    laterals required for each pump station; and after  
3                    determining the number of laterals in each pump  
4                    station, we determine the total laterals in the  
5                    whole unit and we determine also the cost of the  
6                    laterals because laterals are different in cost,  
7                    and we determine the cost of each lateral.

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1 THE WITNESS: And here we have some hand  
2 moves and -- what do you call them --

3 THE SPECIAL MASTER: Side rolls?

4 THE WITNESS: Side rolls, and side rolls  
5 are almost as twice as expensive as the hand  
6 move, so for the hand move we apply different  
7 costs, which is almost about \$2. per feet of  
8 lateral. For the side rolls we apply a different  
9 cost that we received from Riverton supply of --  
10 sprinkler supply from a dealer by the name of  
11 Tom Shepard.

12 Q He's the one who gave you the prices of the  
13 various sprinklers?

14 A The prices of the various sprinklers, so we  
15 used those costs in order to determine the  
16 cost of laterals.

17 THE SPECIAL MASTER: Doctor, we have been  
18 another hour without a break. Do you want to  
19 take five or ten minutes?

20 THE WITNESS: That would be very nice.

21 THE SPECIAL MASTER: All right. Let's  
22 take a break for five or ten minutes.

23 (Whereupon, a short  
24 recess was taken.

25 mesghinna-direct-clear

1 THE SPECIAL MASTER: Okay, we will please  
2 come to order.

3 MR. CLEAR: Yes, Your Honor. I would  
4 like to offer for introduction into evidence  
5 Government Exhibit U.S. WRIR 247, which is  
6 the side roll diagram.

7 MR. WHITE: Could I voir dire for just  
8 one moment, please?

9 MR. CLEAR: Sure.

10 THE SPECIAL MASTER: Sure.

11 MR. WHITE: Would you put it up on the  
12 podium, and maybe I can voir dire from here.

13 VOIR DIRE EXAMINATION

14 BY MR. WHITE:

15 Q Wold, if you know,-- excuse me -- Dr. Mesghinna,  
16 if you know --

17 A That's okay.

18 Q What is the elevation or height of the pipe  
19 which runs down the center of those wheels on  
20 the side roll to which you received the cost  
21 quotations from the man in Riverton, I believe  
22 Mr. Shepard, Tom Shepard?

23 A Yes, yes. The wheels are 76 inches in diameter.

24 Q Seventy-six inches in diameter?

25 mesghinna-direct-clear

1 A Uh-huh.

2 THE SPECIAL MASTER: The wheels are 76 --

3 THE WITNESS: So you have --

4 Q So you are talking about --

5 A So the height of the pipeline would be half  
6 of that, which would be 38 inches above the  
7 ground.

8 Q With respect to the corn which you are growing  
9 in this area, what is the height of the corn?

10 A Corn grows from -- it can grow as high as  
11 probably six feet.

12 THE SPECIAL MASTER: That's an interesting  
13 question. With respect to the corn we are  
14 growing in this area, that's a real interesting  
15 question.

16 MR. WHITE: No further questions on voir  
17 dire, Your Honor.

18 THE SPECIAL MASTER: I think in regard  
19 to the corn grown in the North Crowheart  
20 area I thought he said just the opposite, you  
21 eliminated the five percent corn --

22 MR. WHITE: The question had to do with  
23 the corn that's being grown in the area which  
24 he done his work, which would extend beyond the  
25 mesghinna-voir dire-white



1 North Crowheart, and all I was trying to  
2 point out is corn grows to six feet and that  
3 pipe is 38 inches. He might have difficulty  
4 in irrigation.

5 THE SPECIAL MASTER: Especially in the  
6 second half of irrigation, that's for sure.

7 MR. WHITE: I have no objection to the  
8 exhibit for illustrative purposes.

9 THE SPECIAL MASTER: Thank you, Mr. White.  
10 United States Exhibit WRIR C-247 is admitted  
11 into evidence. This is a diagram of the side  
12 roll.

13 (Whereupon, United States  
14 (Exhibit WRIR C-247 is  
15 (hereby admitted into  
16 (evidence.

16 THE WITNESS: However, I would like to  
17 make a comment on what has been said.

18 THE SPECIAL MASTER: All right, very well.  
19 Please proceed.

20 MR. WHITE: Do I have rebuttal, Your Honor?

21 THE WITNESS: Okay, we perfectly under-  
22 stand and we perfectly know that the side  
23 rolls that we have in here cannot take corn,  
24 especially before harvest, but there are side rolls  
25 mesghinna-voir dire-white

1 which are up to ten feet that I know of, at  
2 least in diameter.

3 Let's forget that, and for convenience  
4 sake we have assumed that the corn would be  
5 irrigated by hand roll.

6 THE SPECIAL MASTER: Okay.

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DIRECT EXAMINATION (CONTINUED)

BY MR. CLEAR:

Q Well, before the break we were discussing the cost of the field layout and what information you gathered from that. Assuming you have gathered all that information on the costs, what did you do with that?

A Well, you know, there are -- although I don't want to go into details as I have been told there are other things besides the lateral costs. There are the stick-up costs and the valves, and so on, have been included in these costs. Then actually determining the overall costs of all these things, we added it in, we determined the cost per acre of the on-farm system. So what it means is there are several costs that enter into the overall investment costs of capital costs in the irrigation system. One is the on-farms system cost. The second is pipeline network costs. The third is pump and pumping plant costs. The fourth is what you call "Canal and related structure costs". The fifth is drainage costs.

And there is another cost, if we may, which

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1 does not much have to do with the system as  
2 such, but what we term as engineering and  
3 contingencies, and that has been included in  
4 the --

5 THE SPECIAL MASTER: What was that first  
6 word? That was contingencies and -- ?

7 THE WITNESS: Engineering.

8 THE SPECIAL MASTER: Engineering  
9 contingencies.

10 THE WITNESS: Yes.

11 A So for what we have determined to make things  
12 simpler and faster is determined on-farm  
13 system costs on per acre base.

14 Q (By Mr. Clear) You determined the on-farm  
15 system costs on a per acre basis?

16 A Yes. So now we find the cost of pipeline  
17 network and ground our way as we go.

18 Q Okay. Do you want to go onto the pipe network  
19 system? Do you want this other drawing of  
20 the -- I'll show it to you --

21 A This one will do, I guess, (indicating).

22 Q That one will do?

23 A Yeah.

24 Q Okay.

25 mesghinna-direct-clear



1 A I better go up and --

2 Q If you want, yeah. Use your pointer, I think.

3 A Thank you.

4 (Standing at the board.

5 As I have pointed out before, we have been  
6 discussing about this thing so far and also  
7 the valves needed there. Okay. But we have  
8 to -- we have the sprinkler system, we have  
9 the on-farm system, but we have to supply  
10 water to it and we have to know two things:

11 One is, how much water do we supply to it;  
12 and the other thing is, what do we need to  
13 supply it?

14 So the network that starts from the pump  
15 stations up to the farm level, including the  
16 distribution line and field main line are --  
17 we are calling them the pipe network system.  
18 So what we are trying to do now is we're trying  
19 to determine the sizes necessary and lengths  
20 necessary for this pipeline network and find  
21 out and determine the costs of these lines of  
22 the pipeline network..

23 So the pipeline network -- pipeline network  
24 is the network between the pump -- pumps and  
25 mesghinna-direct-clear

1 on-farm systems.

2 THE SPECIAL MASTER: Is this the pipe  
3 network or the pipeline network?

4 THE WITNESS: Pipeline network.

5 Q (By Mr. Clear) On your -- on 247, that  
6 diagram, you have a pumping station and  
7 distribution line serving one field?

8 A Yes.

9 Q Is that in fact how it will operate?

10 A Well, this is a very simplistic way, just to  
11 show how the thing is. But a pumping plant  
12 can serve several fields, only two fields,  
13 or probably even one field. It depends on the  
14 configuration of the area and where we are  
15 in relation in elevations and so on. So in  
16 reality, really there are more than on farms.  
17 that are supplied by a given pump station.  
18 Okay.

19 So the next thing to do is to design  
20 our pipeline network. In order to design our  
21 pipeline network, we have to input the results  
22 that we have got in the on-farm systems design.  
23 So what did we get from the on-farm system  
24 design? From the on-farm system design we got

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1 results in terms of gross irrigation requirements  
2 per irrigation, and we also determined the  
3 irrigation frequency. We also said that we'll  
4 irrigate twice a day and about 120 feet per  
5 day and based on this, we'll determine the Q  
6 or discharge required for a given pumping plant  
7 station.

8 There are, however, many fields, and we  
9 have to determine the number of -- the flow  
10 necessary for that.

11 Q The what necessary?

12 A Flow, F-l-o-w.

13 THE SPECIAL MASTER: Flow.

14 A Yes, flow necessary for each pumping station;  
15 okay? The formula for determining the flow  
16 or discharge is -- I can't state it right away,  
17 just sitting here, if you don't mind.

18 A Q is equal to Discharge GPM --  
19 gallons per minute -- equals 453 times A --  
20 A stands for acres -- times D -- D stands for  
21 gross depths of irrigation, which we have  
22 already found -- divided by F times H -- F is  
23 the irrigation frequency in days, and H is the  
24 number of operation hours per day.

25 mesghinna-direct-clear

1 THE SPECIAL MASTER: The number of -- ?  
2 THE WITNESS: Operation hours per day.  
3 THE SPECIAL MASTER: All right. Operating  
4 hours per day.  
5 THE WITNESS: Yes.  
6 A Okay. Now, we determined the GPM necessary  
7 for a given --  
8 THE SPECIAL MASTER: The what necessary?  
9 THE WITNESS: Gallons per minute.  
10 THE SPECIAL MASTER: Right.  
11 A -- for a given pumping station. If we know  
12 the acreages, then we can determine the flow  
13 necessary; okay. But this is a total flow  
14 that should go out for, say, 20 fills in a  
15 given pump station. This is at the head of --  
16 at the head of the pumping plant. But the  
17 pumping plant distributes to every field and  
18 the amount of water that goes to every field  
19 is different from the other, depending on the  
20 acreage from each field. If there is a line  
21 that goes this way and there are 100 acres,  
22 the amount of water that flows through that  
23 land should be the flow necessary for that  
24 100 acres. If there is a line that passes long  
25 mesghinna-direct-clear



1 distance to supply 500 acres, then it has to  
2 carry the amount of water necessary for 500  
3 acres.

4 In essence, what I'm trying to say is  
5 there are different flows in different pipeline  
6 networks. So we have to size the pipeline  
7 network based on the flows that pass or go to  
8 each of these -- to each of these lines to  
9 serve the acreage there.

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24-1-MN-V6

1 THE WITNESS: Now, in order to size our pipeline  
2 network, we have to make some criterions. The criterion,  
3 for example, one of the criterions that we have used  
4 is to -- not to go above seven feet per second in  
5 velocity. Let's limit ourselves to seven feet per  
6 second.

7 Q . (By Mr. Clear) Why do we do that?

8 A. Well, that is a standard procedure in design of pipelines.  
9 It goes seven to ten and so on. So it's better to  
10 be on the seven-feet per second, which is more conserva-  
11 tive. Okay, so we limit ourselves in that seven feet  
12 per second. The other thing that we have taken into  
13 consideration is when water flows through a pipe,  
14 there will be head losses, there will be losses due  
15 to friction. There will be losses due to friction.

16 THE SPECIAL MASTER: There will be losses due to  
17 friction?

18 THE WITNESS: Yes.

19 THE SPECIAL MASTER: Even in a closed pipe?

20 THE WITNESS: Yes, even in a closed pipe. There  
21 is always friction -- when the water flows through the  
22 pipe, there will be friction on the inside part of the  
23 pipe where the water passes. So in order to over-  
24 come that friction, we need more energy.

25 mesghinna-direct-clear

1 Q. (By Mr. Clear) When you say there will be loss due  
2 to friction, you mean losses of water or losses of  
3 what?

4 A . No, no.

5 THE SPECIAL MASTER: Of energy.

6 THE WITNESS: Of energy.

7 THE SPECIAL MASTER: The loss of pressure.

8 THE WITNESS: Yeah, loss of pressure.

9 THE SPECIAL MASTER: All right.

10 THE WITNESS: So that should be counted for. So  
11 in order to determine that, we will call it sub F  
12 head loss due to friction, we used an equation by  
13 Hazen Williams. This is a standard equation in  
14 civil engineering in pipeline network design.

15 If I remember it correctly, the equation states  
16 that  $H_F$  which is in feet of head loss, equals to  
17 Q, which is in GPM, to the power of 1.852 times the  
18 length times 10.44 over C, which is Hazen Williams'  
19 coefficient to the power of 1.852 times D, the diameter  
20 of the pipe in inches, to the power of 1.852. This  
21 will give head loss in feet.

22 Okay, as it has been stated earlier, when we said  
23 head loss, it is really pressure. But we can relate  
24 it also to feet because in water, two points of one

25 mesghinna-direct-clear

24-3-MN-vb

1 feet of head loss is equal to 1 PSI or one pound per  
2 square inch of head loss. So the head loss that I said  
3 is really pressure loss, but we can relate it to --  
4 in terms of feet by this formulation.

5 Okay. Now, we have all the necessary instruments  
6 and methods of determining the size, the friction losses  
7 and so on so we size our pipes. Okay, after sizing a  
8 pipe in a given pumping plant, there will be several  
9 kinds of size, and the smallest pipe size that we have  
10 used is six-inch pipe.

11 Q. Six inch in diameter?

12 A. Six inch in diameter. And our pipes are from six  
13 to twelve inch PVC, which are plastic pipes.

14 Q. Six to twelve inch what?

15 A. Plastic pipes, PVC; from fourteen inch to thirty-six  
16 inch asbestos cement pipes.

17 THE SPECIAL MASTER: How do you spell the second  
18 word, asbestos --

19 THE WITNESS: Cement.

20 THE SPECIAL MASTER: Oh, cement. Very good.

21 THE WITNESS: The pipeline network I think we only  
22 went forty-eight inch, and forty-two inch and forty-eight  
23 inch of steel pipes.

24 Okay, now, using these pipe diameters and based  
25 mesghinna-direct-clear



24-4-MN-vb

1 on the equations that I gave, we determined the size  
2 of the pipes for each -- for a given amount of flow  
3 in each direction. Okay, then we determined costs.  
4 We have to add the costs of the whole pipeline network  
5 that goes back and forth. In order to do that what  
6 we assumed, which is optional, may not be necessary,  
7 we assumed that the pipes will be covered below ground.  
8 That's not necessary, but that increases the cost of  
9 the pipeline network. That is optional.

10 So we have added to the cost of pipes the cost of  
11 restoring the pipes. The cost of pipes have been  
12 determined from several sources. The PVC pipes, we  
13 have got it from Riverton, from the same dealer I  
14 discussed before, and also from other areas. The  
15 ACP pipes for the Wyoming area we got it from the  
16 Johns-Manville.

17 THE SPECIAL MASTER: Would you spell the first  
18 name?

19 THE WITNESS: J-o-h-n-s.

20 THE REPORTER: And also the last name.

21 THE SPECIAL MASTER: Manville, headquartered in  
22 Denver, Colorado, world headquarters now.

23 THE WITNESS: Yes, and we received the costs from  
24 them. And the steel pipes I believe we used the costs

25 mesghinna-direct-clear

4-5-MN-v1b

1 from Dodge Guy for heavy construction.

2 Q. (By Mr. Clear) Dodge?

3 A. Dodge Guy; Dodge like a car.

4 THE SPECIAL MASTER: You didn't propose any use  
5 of pipe over thirty-six inches over the asbestos  
6 cement side in the pipeline network systems, though,  
7 did you?

8 THE WITNESS: I didn't, I used the steel pipes.

9 THE SPECIAL MASTER: Yeah, but what size is your  
10 biggest pipes?

11 THE WITNESS: Forty-eight inch.

12 THE SPECIAL MASTER: Forty-eight?

13 THE WITNESS: In the pipeline network, and that is  
14 steel pipe.

15 Okay, after we determined the costs of the --  
16 what do you call it -- of this material cost we call  
17 it, we have to add it in establishing costs below the  
18 ground. But I would like to make clear this is not  
19 really necessary, but we have this in considering  
20 the cost of the site. The cost of installation was  
21 added to it, and using the added cost of the pipe  
22 costs plus the installation costs, and we must apply  
23 each length. What it means is a six-inch pipe of  
24 a cost per feet. If we have one thousand length of  
25 mesghinna-direct-clear

1 six-inch pipe, then we must multiply it by that cost.  
2 If we have twenty-inch pipe, then we must multiply that  
3 length of twenty-inch pipe necessary by the cost per  
4 feet. So we did this for all the units, for all the  
5 pumping plants, and we determined the cost of each  
6 pumping plant of pipeline network.

7 After we determined that, I believe just to be on  
8 the safe side, we multiplied it by an extra five percent.  
9 There might be some things necessary as to pressure  
10 reduced and so on and so forth. In this matter we  
11 increased it by five percent, the cost of -- after  
12 determining the per acre cost, the per acre cost. The  
13 per acre cost of the pipeline network is the total  
14 cost of pipeline divided by the total acres of each  
15 pumping station. Then after determining each pumping  
16 station, we determined the cost of a given unit like  
17 North Crowheart or South Crowheart or whatever it is  
18 and that way we determined the pipeline network cost  
19 on a per-acre basis.

20 As far as pipeline network is concerned, I tried  
21 to make it as concise as possible to this point.

22 Q. (By Mr. Clear) When we were talking about the on-farm  
23 system, you mentioned in there, you mentioned one  
24 of the efficiencies and one was a distribution efficiency.

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1 Is that an efficiency in a pipeline?

2 A. Okay, let me go into it. I think that's a very  
3 important point. I think we are clear on the on-farm  
4 efficiency or application efficiency. But in my  
5 earlier discussion I said that there are two other  
6 efficiencies necessary. One of them is the distribution  
7 efficiency, which is between the pump and on-farm  
8 system. And there's another efficiency called conveyance  
9 efficiency between the diversion point of the river  
10 and the pump station. So in this area we need to know,  
11 in my discussion area here, we need to know the  
12 efficiency of the pipeline network.

13 Again, in pipeline network there is no hard evidence,  
14 no one can find out what efficiency of a certain pipe  
15 is. But it is generally believed that conduits,  
16 closed pipes, have an efficiency between ninety --  
17 above ninety percent. They go probably up to ninety-  
18 eight percent or ninety-seven percent. Based on the  
19 kind of configurations that we have and based on our  
20 professional judgment, we came up with a ninety-five  
21 percent distribution efficiency, and we have allowed  
22 for that in our design of the flow that I have stated  
23 earlier, so we increased the flow. This does not mean  
24 that -- when I say the flow, we are designing the pipes

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4-8-MN-vb

1 so that when I talk about the flows, this has nothing  
2 to do with the water claim. This is for the pipe.  
3 We are sizing the pipe to take care of the loss,  
4 so we did allow a loss in the pipes of five percent  
5 loss, which is not much, due to leakage and --

6 Q. Pardon?

7 A. Due to the leakage in the pipes and, you know, as a  
8 mismanagement and so on in the pipes. So as far as  
9 I am concerned, I think this is the most way I can  
10 make it as concise as possible on the pipeline network.

11 Q. Okay. That brings us to the pump and the pumping plant.

12 A. Yeah. Okay, the pump and pumping plant is -- first  
13 of all, let me make it clear. Pump and pumping plant,  
14 what we mean by this is the pumping plant includes  
15 the structure --

16 THE SPECIAL MASTER: Includes what?

17 THE WITNESS: The structure.

18 THE SPECIAL MASTER: Structure of what, the  
19 pumping plant or several pumping stations?

20 THE WITNESS: Yes.

21 THE SPECIAL MASTER: Of several pumping stations?

22 THE WITNESS: Yes, yes.

23 THE SPECIAL MASTER: All right.

24 THE WITNESS: This pump station here requires this  
25 mesghinna-direct-clear

1 structure in order for the water to enter to the  
2 pump. So we include the pump.

3 THE SPECIAL MASTER: Pump and cylinder and some  
4 screens?

5 THE WITNESS: The screens, yes, screens and  
6 structures.

7 THE SPECIAL MASTER: Yeah, yeah.  
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1 Q. (By Mr. Clear) I have put on the board the United  
2 States Exhibit WRIR C248. Can you describe that?

3 A. Okay. I think this one shows almost a complete picture  
4 of the whole thing. Here we have a diversion structure  
5 (witness indicating). First of all this is the river.  
6 Let's assume this is the Wind River (witness indicating)  
7 and here we have the river and this is called the  
8 diversion structure (indicating). We have the head  
9 canal structure in here (indicating). We have the  
10 spillway in here and water comes --

11 THE SPECIAL MASTER: Did you find the diversion  
12 structure already in place to serve the -- this is  
13 kind of a cruel question -- the North Crowheart?

14 THE WITNESS: Yes.

15 THE SPECIAL MASTER: In the future? Is it already  
16 in place?

17 THE WITNESS: Yeah, we know where it is going to be.

18 THE SPECIAL MASTER: Where it is going to be put?

19 THE WITNESS: Its location and elevation and so on.

20 THE SPECIAL MASTER: All right.

21 A. So --

22 MR. WHITE: Well, Your Honor, I don't think he  
23 answered the question.

24 THE SPECIAL MASTER: Well he said he knows where  
25 mesghinna-direct-clear

1 they are going to put it so I guess there is not one  
2 in place.

3 MR. WHITE: Thank you.

4 Q. (By Mr. Clear) When you got to canals and related  
5 structures, will you describe the diversion structures  
6 that you have --

7 A. Yeah, we'll discuss it quite a bit, if necessary.

8 Okay. So this is a diversion structure (indicating).  
9 There are gates and so on. Here there is a spillway  
10 here. You know, and so on. And the water is diverted  
11 to the canal, let's call this one North Crowheart  
12 Canal, that will make things simpler. And the pump  
13 station is in here (indicating), you know water  
14 will enter into the pump station through this and  
15 then the pump will pump water and distribute it  
16 through the pipeline network as we see it in here  
17 and then the pipeline network will distribute it  
18 through the laterals.

19 THE SPECIAL MASTER: And did your work include  
20 the cost of pump stations and design pump stations?

21 THE WITNESS: Yeah, it will include the cost of  
22 pump stations and I am almost near to it now.

23 THE SPECIAL MASTER: All right.

24 THE WITNESS: Okay. In fact, let me go through it.

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1 THE SPECIAL MASTER: All right. Very good.

2 THE WITNESS: Okay. In order to determine the  
3 cost of the pump station which I said it includes  
4 the pump itself and the prime movers of the pump  
5 station it also includes the structures, it also  
6 includes the valves, manifolds and so on necessary.  
7 Again, I would like to state in here that it's not  
8 really necessary to have an over structure in a pump  
9 station but we have included the cost for over structure  
10 just to be on the safe side. And that can always be  
11 subtracted if it is not necessary but at any rate  
12 we have included those costs and other costs, such as  
13 parking lots and so on and so on.

14 In order to design a pump what do we need? What  
15 do we have to know? What is the most important  
16 thing? The most important thing in order to know a  
17 pump capacity -- pumps are -- there are, if someone  
18 wants to go and wants to buy a pump from a pump dealer  
19 he has to know certain things and those things are  
20 horse power, what size of horse power do you want?  
21 These are the questions that the dealer is going to  
22 ask first. The second thing is he would like to know  
23 what kind of head are you talking about how high are  
24 you planning --

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1 THE SPECIAL MASTER: To lift your water?

2 THE WITNESS: To lift your water. And  
3 the other thing he's going to ask is how much flow  
4 are you talking about, how much flow do you expect  
5 your pump to pump out water from the canal? So these  
6 questions should be answered so that someone would  
7 know about the costs of pumps.

8 Okay. What are these things? Again, we have to  
9 go back to pipeline network. You see what we are doing  
10 is we first determined the climate, then we entered  
11 the necessary data to determine the evapotranspiration  
12 from the climate, then we entered the results that we  
13 got from evapotranspiration to on-farm system, and  
14 then the result of on-farm system entered into pipeline  
15 network. Now we need the results. We get from pipeline  
16 network in order to design our pump station. So what  
17 did we get from the pipeline network? From the pipeline  
18 network I indicated that we determined the head losses  
19 of pipe so that is a very important thing in order  
20 to determine the capacity of the pump. The other thing  
21 that is necessary in order to determine the capacity  
22 of the pump meaning that the head that -- that the lift  
23 it should serve. We need to know the static head.

24 The static head is nothing but the elevation between the  
25 mesghinna-direct-clear

1 pump station and the high point in field. We have to  
2 know this. The other thing that we have to know is  
3 we have sprinklers there so they need pressure. When  
4 the water comes out from the sprinkler, it requires a  
5 certain amount of pressure in order to irrigate  
6 uniformly. And we assumed fifty-five PSI which is about  
7 127 feet of head. Really nowadays you can go with much  
8 less than that in sideroll or on hand-move, less than  
9 fifty-five PSI. We can go like forty or even forty-five  
10 PSI. But we have used that in order to be on the  
11 safe side because the higher head, the higher the head  
12 you pump out, the higher the cost of your pump will be.  
13 Not only that, your energy will be higher every year.

14 Okay. So then these three things, the head loss  
15 or friction loss in the pipes plus the static head  
16 which is the elevation difference plus the pressure  
17 required for the sprinklers added all together are  
18 called total dynamic head. In reality this is the  
19 head that the pump should pump out in order to bring  
20 water to the point of interest.

21 Okay. One thing that we have entered into this  
22 is when we determine the head loss, the friction loss  
23 in the pipes, we increase it also by five percent  
24 in order to account for connections here and there,

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1 joints here and there which is hard to estimate in  
2 terms of head losses. So we increased this. So  
3 then we determined the total dynamic head. This is  
4 the head that the pump is supposed to pump out water.  
5 This is the lift that it's going to pump out water.  
6 Okay. Now from my former discussions I gave you Q  
7 or the discharge required in a given pumping station.  
8 That is, a pump station might have twenty fields, I  
9 said before, and we determine that flow necessary for  
10 all these fields in GPM, gallons per minute. Okay,  
11 so now we have these two things. We have the total  
12 dynamic head, we have the discharge required from the  
13 pump. Also, in my former discussion, I said that three  
14 things are important to know in order to design a  
15 pump station. And I said the total dynamic head which  
16 we just found out what it is, the discharge or flow  
17 in GPM which we found, so one thing is left and that  
18 is the brake horsepower.

19 Q. What is the first word, what horsepower?

20 A. Brake horsepower.

21 THE SPECIAL MASTER: Brake.

22 THE WITNESS: Brake horsepower. That is the  
23 horse power in the pump required.

24 Okay. Now how we determine brake horsepower?

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25-7-LM-vb

1 Brake horsepower is a function of total dynamic  
2 head and discharge. And BHP, brake horsepower,  
3 if I remember correctly, is the Q in GPM times the  
4 total dynamic head divided by 3,960 again divided by  
5 the efficiency of the pump. So if we go and do this  
6 for each pump station like this will determine the  
7 brake horsepower..

8 THE SPECIAL MASTER: This is fascinating to me.  
9 Is that formula devised to the person to whose name  
10 has been given to it, the formula? Is that from the  
11 British classification of horse power, brake horsepower?

12 THE WITNESS: Yeah, it is a British classification.

13 THE SPECIAL MASTER: Okay.

14 THE WITNESS: Okay. So this is the way on how  
15 to determine the brake horsepower..

16 Q. (By Mr. Clear) Uh-huh.

17 A. Okay. The next thing is -- now we know the brake  
18 horse power meaning we know the pump size. Someone  
19 can go to the dealer for pumps, Berkley pumps for  
20 that matter. He knows all the necessary constituents  
21 there and can ask for the pump cost.

22 Okay. But we did not go to the pump dealer and  
23 as the costs, you know, of each. We asks several costs  
24 but that does not really help us very much because there  
25 mesghinna-direct-clear

5-8-LM-vb

1 are, as I said, other structures necessary there.  
2 So we depended on the works that have done by the  
3 USBR in this aspect.

4 Q. Bureau of Reclamation?

5 A. Bureau of Reclamation.  
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1 A But we did not take their word as a Bible,  
2 and we have also seen other projects and --

3 THE SPECIAL MASTER: Did you inquire of  
4 pump manufacturers in the Rocky Mountain West  
5 to buy them directly from them rather than  
6 from dealers?

7 THE WITNESS: Well, when I am saying  
8 "Dealers" I meant the overall industries,   
9 including dealers and --

10 THE SPECIAL MASTER: Distributers, jobbers?

11 THE WITNESS: Yes.

12 A Okay. So as I have indicated if, and you'll  
13 see it in my summary report, I have cited the  
14 reference, and those I have given in my  
15 deposition, the reference on the different  
16 graphs: used in determining the cost of pumping  
17 station by USBR and we mostly follow that one.  
18 But also, we have also compared it with other  
19 costs that have been done before this time, and  
20 we were satisfied with our results and in  
21 general what those graphs are. I don't know if  
22 it is necessary to go one by one,

23 Q (By Mr. Clear) No, I don't think so.

24 THE SPECIAL MASTER: You can summarize it.

25 mesghinna-direct-clear

1 A Just to have what you call "Q flows", the  
2 cubic feet per second. Then you have the  
3 total dynamic head, then you get what you call  
4 the cost of pumping and then from -- based on  
5 that, and determine the cost of structures  
6 and so on. It is just a mechanical thing.  
7 But that is 1968 prices.

8 Q Um-hum.

9 A But --

10 THE SPECIAL MASTER: Then the prices in  
11 your report are 1968 prices?

12 THE WITNESS: No. I will come to it.

13 A Those guidelines given by the Bureau of  
14 Reclamation are 1968 costs, but we indexed them  
15 to 1979 costs, because all our costs are 1979  
16 costs. Everything is based on 1979.

17 So after we came up with the overall  
18 pumping plant costs, really what we did is  
19 we have all these different graphs and we  
20 lumped them up into one graph, you know, much  
21 easier. You can -- I mean the office studied  
22 several of them and we lumped them up to one  
23 graph.

24 What you do is first find the cost of a  
25 mesghinna-direct-clear



1 pump based on the pump, then you can determine  
2 overall costs. One graph would do -- in fact  
3 two graphs, really. The first graph determines  
4 based on pump costs, then determine the pumping  
5 plant costs.

6 THE SPECIAL MASTER: Give me that  
7 distinction again. What additions are there  
8 for pumping plant costs not included in pump  
9 costs?

10 THE WITNESS: Okay. Let me clarify it  
11 more, then.

12 The graphs given by USBR are several  
13 graphs. One is for the pump itself; another  
14 one is for manifolds; another one for the  
15 structures, and so on. Okay.

16 So what we did is first we went on and  
17 determined different size of pumps in using  
18 that one -- using those guidelines, using  
19 those graphs.

20 THE SPECIAL MASTER: Um-hum.

21 THE WITNESS: And then we said there must  
22 be some kind of relationship in here. So we  
23 related it to just the pump costs.

24 If I determined the pump costs, how can  
25 mesghinna-direct-clear

1 I determine the overall pumping plant costs?

2 Just by knowing if, say, for example, the  
3 pump cost is, let's say \$50,000, what will  
4 be the cost of the overall pumping plant?

5 Okay, then we made a graph out of their graph,  
6 one graph instead of four, five. We made one  
7 graph and by just knowing the cost of the  
8 pump --

9 THE SPECIAL MASTER: You extrapolated --

10 THE WITNESS: -- we extrapolate and  
11 find out the cost of all the whole pumping  
12 plant. That cuts the work and the tediousness  
13 of it.

14 So we did this for all the pumping plants  
15 in all the five units, and after determining  
16 the cost of each pumping plant, we added the  
17 cost of each pumping plant. After adding the  
18 cost of each pumping plant, then we determined  
19 the cost per acre on the pumping plant.

20 MR. CLEAR: Your Honor, I think he's  
21 been on the stand another hour, and --

22 THE SPECIAL MASTER: You divided the number  
23 of acres in the unit to the cost and got the  
24 cost of the pumping plant; is that it?

25 mesghinna-direct-clear

1 THE WITNESS: That's about it, yes.

2 THE SPECIAL MASTER: Okay. It's four  
3 o'clock. Are we going to set the record today,  
4 or should we adjourn to tomorrow?

5 MR. CLEAR: He's been on the stand since  
6 eight o'clock this morning and I think in  
7 fairness to the witness he's been an accurate  
8 witness, but --

9 THE SPECIAL MASTER: He's already put in  
10 an eight-hour day; he doesn't have to put in  
11 a nine-hour day.

12 We will be in session again at eight  
13 o'clock in the morning. We will go from  
14 eight until two if you want to bring sandwiches  
15 and work straight through, or we could  
16 break at twelve --

17 MR. SACHSE: Could we go --

18 MR. WHITE: I'd already agreed to let Mr.  
19 Sachse go home at noon.

20 THE SPECIAL MASTER: Did you?

21 MR. WHITE: And I'd like to ask if we  
22 bring sandwiches that we go to one o'clock.

23 MR. SACHSE: I could catch the plane if  
24 we went until one o'clock.

25 MR. MEMBRINO; Your Honor, it's rough to

1 get back east --

2 THE SPECIAL MASTER: There's no way.

3 I moved west and -- just a minute; the record  
4 is closed. We'll be in session again at  
5 eight o'clock in the morning.

6 (Proceedings recessed  
7 (at approximately  
8 (4:10 p.m.

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REPORTERS' CERTIFICATE

State of Wyoming )  
 : SS  
 County of Laramie )


We, Lamont Miller, Mary Nelson and Monika Fleischli, Registered Professional and Certified Reporters and Notaries Public, hereby certify that we did at the time, date and place, as set forth, report the proceedings had before the Honorable Teno Roncalio, Special Master Presiding, in stenotype; that the foregoing pages, numbered 3978-4196, inclusive, constitute a true, correct and complete transcript of our stenographic notes as reduced to typewritten form under our direction.

We further certify that we are not agents, attorneys or counsel to any of the parties hereto, nor are we interested in the outcome thereof.

Dated this 23rd day of April, 1981.

  
 LAMONT MILLER  
 Registered Professional  
 Reporter

  
 MARY NELSON  
 Registered Professional  
 Reporter

  
 MONIKA FLEISCHLI  
 Certified Shorthand Reporter

